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SEASONAL, DIEL AND SPAWNING HABITAT OF THE RARE MUSCADINE DARTER (*PERCINA* SP.) IN THE CONASAUGA RIVER, GEORGIA

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ABSTRACT

Habitat use of the undescribed muscadine darter (*Percina* sp. cf. *macrocephala*) was investigated in the Conasauga River, Georgia and compared to available habitat. In addition to observations made during the day, nocturnal and spawning habitat observations were included for analysis. Seasonal habitat use was also compared (winter vs. spring/summer), and annual variation (1999 vs. 2000) was assessed. In general, the habitat used by darters (water depth and velocity, substrate type) differed from surrounding habitat, suggesting that they selected particular habitat characteristics. Available water depths differed between 1999 and 2000 during the spring/summer; correspondingly, darters used different depths between years. All three measured habitat variables differed from winter to spring/summer, and darters used different habitats during different seasons. During spawning, darters used the same habitat where they were found during the day, except that they selected sand substrate more often. At night, darters were found in shallower water than they were during the day. Understanding these habitat relationships will aid in the protection of this rare species.

INTRODUCTION

Habitat utilization models are used by resource managers and researchers as a means of protecting biodiversity. Habitat suitability criteria are typically derived from observations of fishes at certain points and include the associated physical features of water velocity and depth, substrate type, and instream cover (Bovee, 1982). Such models are often based on limited data, however, and may not accurately reflect the habitat used by a particular species (Orth, 1987). Expanded models which include seasonal, diel and spawning habitat uses more accurately depict the full range of habitat used by a species and may be more useful as management tools.

Life history information for all life stages of fishes is critical for implementation of management plans for species protection, and in some cases may prevent the need for listing under the Endangered Species Act. One of the most critical information needs for species protection is habitat use and how this is coupled to population dynamics. Compounding the lack of this information for many aquatic species is our poor understanding of how to approach studies of habitat use. Most investigations of habitat use take into account only observations of diurnal habitat used by adults, but fishes may use very different habitats for foraging, spawning and resting. Examination of habitat use during all of these activities and for all life stages must be conducted for a complete habitat assessment.

The objective of this study was to assess habitat use of the undescribed muscadine darter (*Percina* sp. cf. *macrocephala*) in the upper Conasauga River, Murray County, Georgia. Habitat use during diel, seasonal, and spawning periods was investigated. In addition, the spawning behavior of the species was examined in the field. This information could be used for predicting darter occurrence, protecting critical habitat, and potential restoration efforts.

Study Species

Previously thought to occur in the Tallapoosa, Black Warrior and upper Coosa river systems, recent analysis has shown the population of this undescribed darter in the upper Coosa system to be a distinct species (J. D. Williams, pers. comm.). This species is largely restricted to the Conasauga River, the last stronghold of many rare or imperiled aquatic species. *Percina* sp., muscadine darter, has always been considered rare, and especially sensitive to environmental perturbation (Wieland and Ramsey, 1987; Etnier and Starnes, 1993). Very little published information on aspects of biology or ecology of the muscadine darter exists.

METHODS

The study site included approximately 0.5 km in the Conasauga River, Murray Co., GA. Sample transects began at the Cottonwood Patch Camp (Chattahoochee National Forest, 0.81 km upstream from the confluence with the Jacks River; 8.8 km ESE of Conasauga, TN) and included the area 0.5 km upstream of this entry point.

Habitat observations were made during 14 sampling trips in 1999 and 2000. Spring/summer habitat (diurnal, or focal) was assessed 18 May - 5 August 1999 and 15 May - 19 July 2000 (at 2 - 4 week intervals). Winter samples were taken on 12 and 28 February 2000. Nocturnal measurements were taken 7 and 30 June and 19 July 2000. On each sampling trip 6-10 snorkel transects were performed. The exact location where a darter was observed (focal observation) was marked with a colored weight; individual fish were only counted once. In addition, available physical habitat data were collected along 3-6 transects. Transects representing available habitat were placed within the areas sampled for focal observations and were perpendicular to the stream channel. Measurements were taken at three points along each of these transects (average width of the stream was < 20 m).

Water velocity and depth, substrate type and percent instream cover were measured at each of these points. Water velocity was measured using a Marsh-McBirney flow meter using standard recommended methods (0.6 depth from stream bottom). Predominant substrate composition was estimated using a modified Wentworth scale (sand, gravel, cobble, bedrock and silt). Virtually no instream cover was found during focal or available habitat observations, so this variable was eliminated from analysis. Chi-square goodness of fit tests was used to assess differences among focal and available habitat, and to compare spawning and nocturnal habitat use to diurnal habitat use.

When darters were observed spawning, detailed observations of their behavior were made and videotaped. Videos were reviewed in order to compile a description of spawning behavior. Water temperature was taken at each spawning observation site. For the purposes of habitat analysis, spawning pairs were treated as one observation.

RESULTS

Habitat Analysis

Muscadine darters preferred habitat that was distinguishable from what was available (Fig. 1) for all three variables measured (water depth, velocity and predominant substrate type). Available water depth was greater in 2000 than 1999 ($\chi^2 = 20.8$, $p < 0.02$), and diurnal focal depth also was greater in 2000 ($\chi^2 = 31.4$, $p < 0.02$). Water velocity and substrate type did not differ between years for focal or available habitat measurements. During the winter (February 2000), darters selected habitat with lower water velocity and cobble substrate, although depths chosen did not differ from available habitat (Fig. 2). Available winter habitat was shallower with lower water velocities and smaller substrate size than spring/summer available habitat, and focal habitat was similar for water depth and velocity but darters used larger substrate size than what was used during spring/summer (all $p < 0.02$).

At night, darters used shallower water than they did during the day ($\chi^2 = 17.95$, $p < 0.02$; Fig. 3) although other habitat variables did not differ from diurnal focal habitat. Spawning habitat did not differ from focal habitat, except that spawning tended to occur more often in sand substrate ($\chi^2 = 10.27$, $p < 0.02$; Fig. 4).

Spawning Behavior

A total of 20 pairs of darters was observed spawning (n = 64 spawning acts) in 1997 (23 June), 1998 (29 May), 1999 (18 May) and 2000 (7 June). Courtship activity was observed on 9-10 June and 18 July 1999 and 15 May 2000. Water temperature during these times varied from 16-22 C. Males and females appeared to be approximately the same size. During the spawning season, females had distended abdomens and were less brightly colored than males. Males developed a green stripe, which extends the length of the body above the lateral line, and lateral blotches.

During courtship males followed an individual female, occasionally nudging her side or resting on top of her. Males were aggressive when following a female, and chased other males from the area. During spawning the male positioned himself beside the female, the pair vibrated, and the vibrating action caused the caudal peduncle of the female to become buried. At this time gametes are presumably released and buried in the substrate.

In 21 spawning acts a sneaker male [i.e. one that darts in and attempts to release gametes with a spawning pair (Gross, 1984)] attempted to intervene in the spawning act by positioning himself alongside the spawning pair. Sneakers successfully joined spawning in 10 of these attempts and were chased away by the male in the other 11.

DISCUSSION

Muscadine darters in the Conasauga River tend to occur in sandy runs with moderate water velocity and relatively shallow water depth, a habitat characterization not substantively different from previous qualitative habitat descriptions for the Tallapoosa form from similarly sized streams (Wieland and Ramsey,1987; Etnier and Starnes, 1993; Freeman et al., 1997). Freeman et al. (1997) found that adults of the Tallapoosa form of the muscadine darter preferred relatively coarse substrate rather than sand, and rocks, ledges or riverweed cover in Enitachopco Creek, and that larger individuals (> 35 mm SL) preferred higher water velocities than smaller individuals (< 35 mm SL). Wieland and Ramsey (1987) reported muscadine darters from the main channel of the Tallapoosa River in areas of relatively swift current with predominantly gravel substrate, suggesting that the habitats used may vary with water body size or correlated habitat variables. In this study, the habitat used by muscadine darters changed seasonally and annually. These changes usually mirrored available habitat. At night, muscadine darters occupied very shallow water. Spawning habitat differed from other focal habitat only in the prevalence of sand substrate.

Studies have shown shifts in habitat use among years and seasons are not uncommon (Baltz et al., 1989; Bozek and Rahel, 1992). Bonneau and Scarnecchia (1998) found bull trout and cutthroat trout to occupy lower velocities during the winter than in the summer, and Freeman and Freeman (1994) found that amber darters moved to deeper water with faster water velocities during fall. Additionally, amount of available habitat can affect habitat use (Shirvell, 1989) as can food availability (Fausch, 1984; Wilzbach and Cummins, 1986). Competition, both intra- and interspecific, can also affect habitat use (Schlosser, 1987).

Other studies have also found that fishes move into more shallow water at night (Greenberg, 1991; Johnson and Covich, 2000), and this is true for the Tallapoosa form of the muscadine darter (Costley, 1998). Costley (1998) also found that at night muscadine darters used areas with lower water velocity at one of four sites studied. Presumably this is a predator avoidance strategy, but fishes may also be seeking areas for rest where they do not have to expend energy maintaining position in fast-flowing water.

Although this study provides data on habitat use of muscadine darters at one site in the Conasauga River, it is not known whether the habitat used here is utilized across the range of the species. Other studies have shown that habitat models developed at one site may not be applicable to other sites (Bozek and Rahel, 1992; Freeman et al., 1997, Klyce, 2001). Factors relating to these differences may include differences in stream geomorphology, habitat quality and availability, food availability and competitors/predators. Although the Tallapoosa form of muscadine darter is a different species, the water velocities and depths used by the Conasauga form fall within those reported by Freeman et al. (1997) for the Tallapoosa form. Information on the fish community may also shed light on habitat use. Competition (interspecific) and predation may narrow the habitat use of muscadine darters. Conversely, at this study site, densities of muscadine darters may be high (intraspecific competition), such that some individuals are forced into suitable rather than optimal habitat. If this is the case, habitat models may be broader than expected.

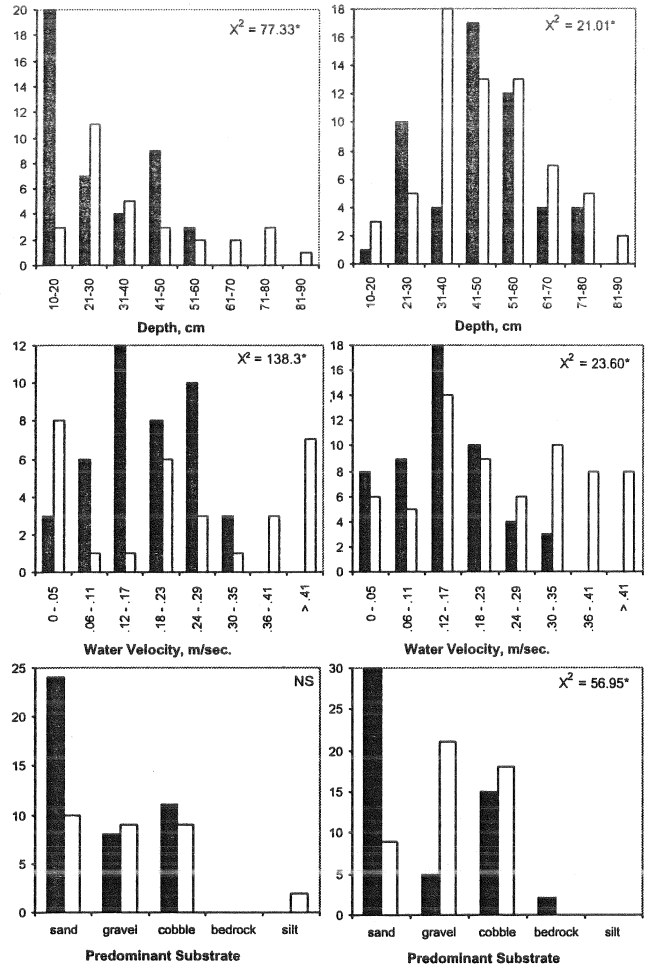

Figure 1. Number of observations (y axis) by habitat categories (spring/summer pooled). A is 1999 (focal n = 43, available n = 30); B is 2000 (focal n = 52, available n = 66). Black bars, focal habitat use; white bars, available habitat.

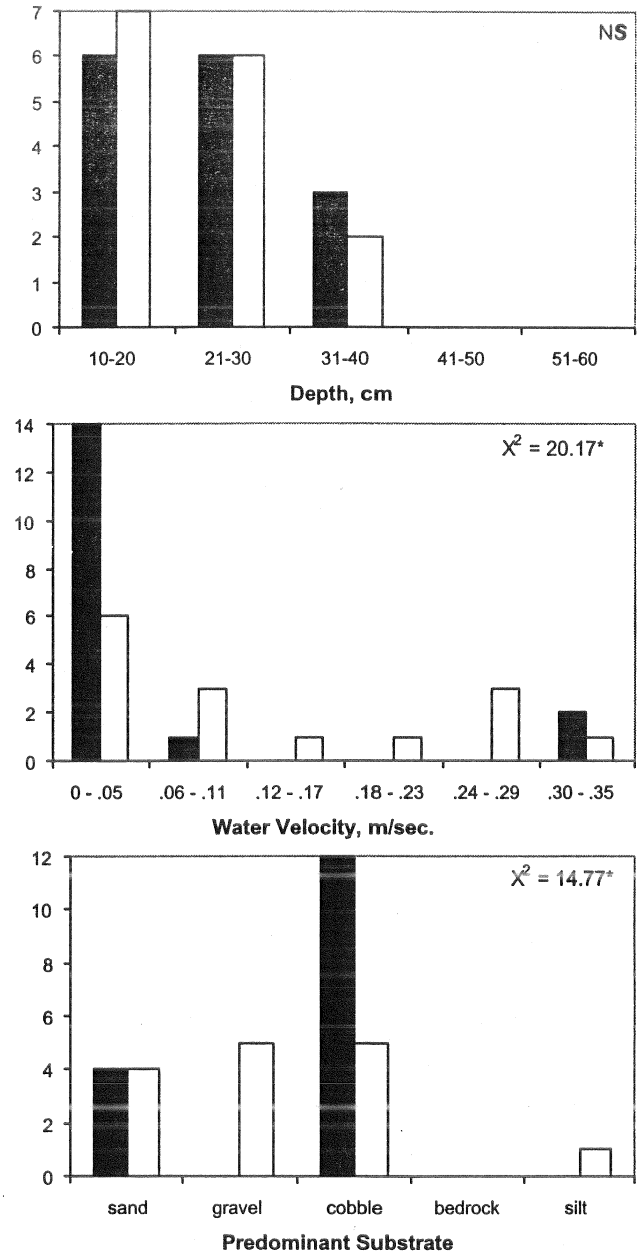

Figure 2. Number of observations (y axis) by habitat categories in winter. Black bars indicate focal habitat use (n = 16); white bars are available habitat (n = 15).

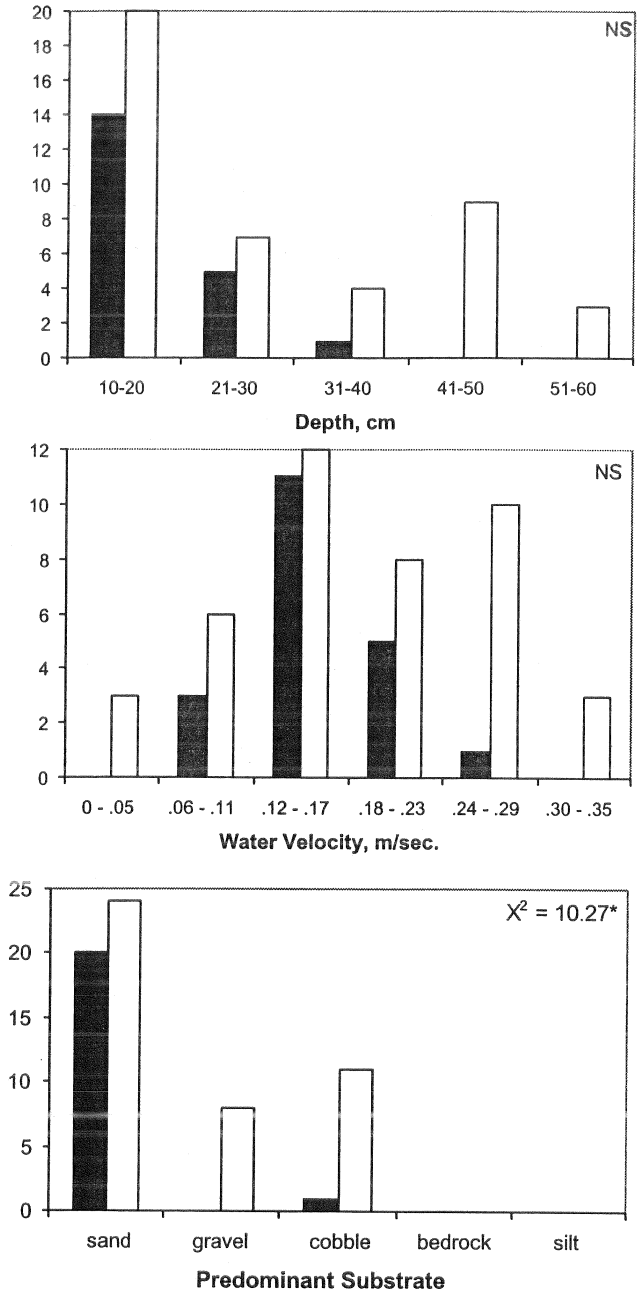

Figure 3. Number of nocturnal observations (y axis) by habitat categories. Black bars indicate focal habitat use (n = 12); white bars are available habitat (n = 52).

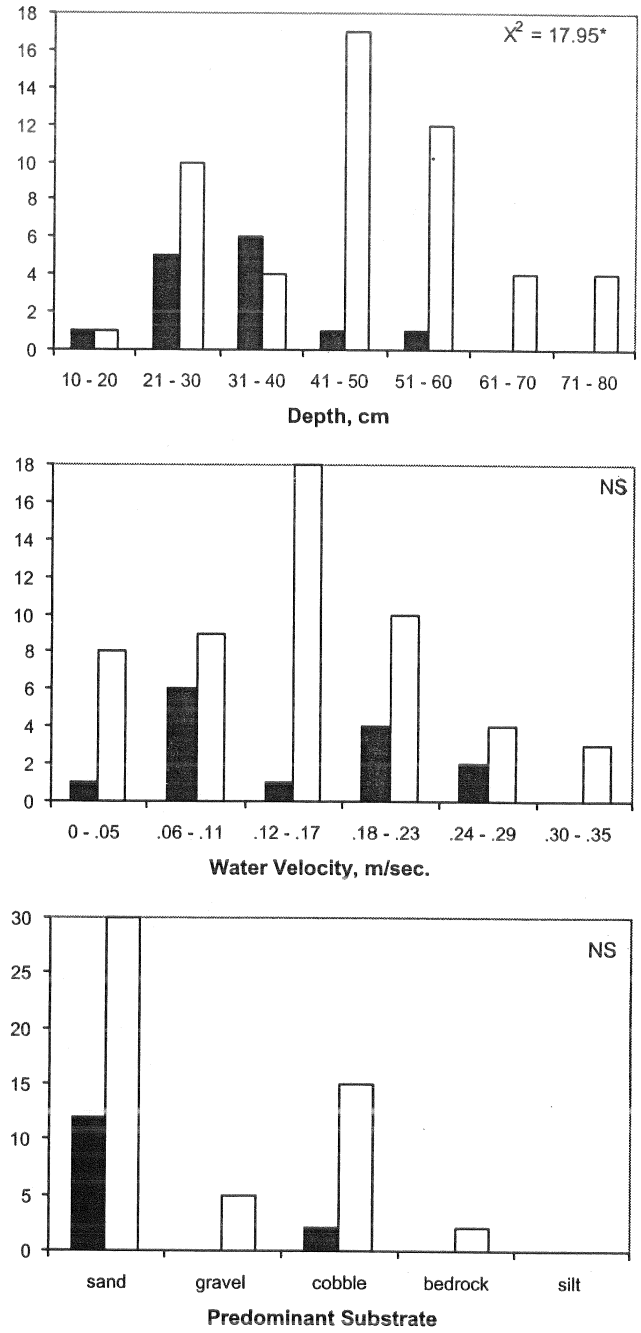

Figure 4. Number of spawning observations (y axis) by habitat categories. Black bars indicate focal habitat use (n = 10); white bars are available habitat (n = 43).

Muscadine darters have the egg-burying spawning mode typical of *Percina* (Page, 1985). The presence of sneaker males has not been well-documented for species of *Percina*, but is not surprising for egg-buriers. This spawning mode affords opportunity for additional males to get close to spawning pairs and release sperm.

Knowledge of habitat use for this rare fish will assist in conservation efforts for the muscadine darter as well as aid in conservation of the fish community of the Conasauga River. Understanding habitat use is an essential prerequisite for restoration efforts, as well as predicting persistence and occurrence of fishes of special concern. Any model of muscadine darter habitat should incorporate the full range of habitats used by the fish throughout its life cycle. Future work should be aimed at understanding habitat use of larvae and juveniles, as well as understanding the relationship between habitat use and population dynamics.

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